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Setting up of a Kenya National Domestic Violence Call Center (K-NDVCC): Prototype and Pilot Implementation

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ABSTRACT

Domestic violence can involve men to women, men to children, women to children and sometimes women to men. Domestic violence in Kenya is mostly prevalent in middle-income and lower-income levels of the society. In this paper, a prototype system is implemented to administer and manage a national domestic violence call center. This is a GIS-based call center system supporting distress calls by: (i) automatically identifying callers' locations, (ii) Quickly assessing accurate spatial information from its database about nearby advocate resources and reporting back to the caller, the identified advocate, and (iii) publishing maps in Keyhole Markup Language for viewing in software supporting open standards such as Google Earth. The system was validated using sample data collected from Juja location. This prototype shows promise of being able to offer rapid and timely responses to domestic violence (and other) distress requests utilizing geospatially enabled technologies.

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1. Introduction

Domestic violence, defined as abuse involving intimate partners, is the most common cause of injury to women (Chambliss et al 1995). Domestic violence occurs and can involve men to women, men to children, women to children and sometimes women to men. Frequently, the violence is a combination of physical, sexual and psychological abuse that occurs in a cyclic and intensifying pattern that can ultimately result in serious assaults with weapons or even death (UNICEF, 2000). Domestic violence also encompasses economic control and progressive social isolation. It is acknowledged that domestic violence is prevalent in all racial, educational, geographic and socio-economic segments of society. The results, from a baseline survey among women in Nairobi, (FIDA, 1998) identified the various modes in which domestic violence is propagated in Kenya as captured in Figure 1.

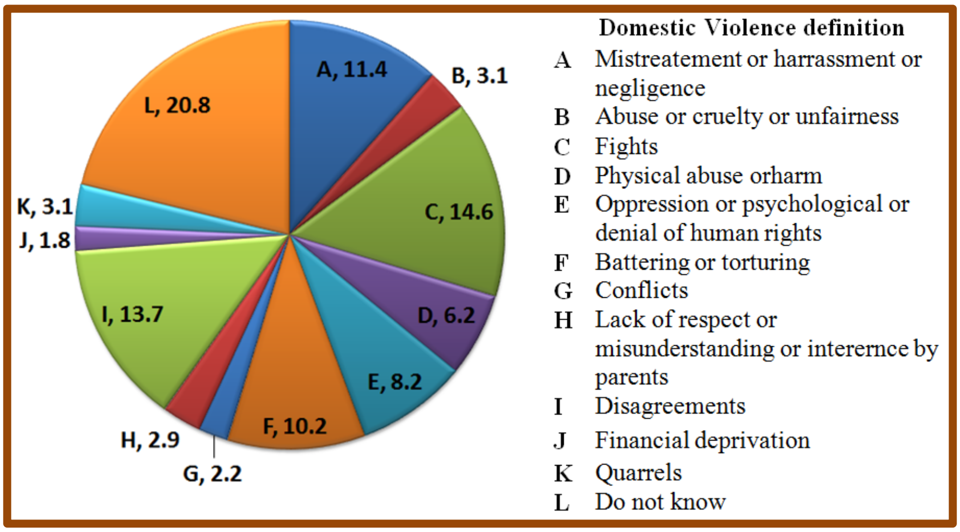

Figure 1: Varying definitions of domestic violence.

Some factors that precipitate domestic violence have been identified as discussed hereafter. Men who show inadequacy, jealousy or controlling, suspicious behavior are more likely to be involved in spouse violence. Domestic violence in Kenya has been a long standing issue, with experts showing that it is on the rise (Majtenyi, 2010). Domestic violence in pregnancy is also highly correlated with the male patient's use of injectable drugs. Gielen et al (1994) found that better education opportunities for women were associated with higher risks of domestic violence, serving to redress the balance of power within the relationship and bolster the man's self-esteem and control.

With rising levels of poverty, rape incidences have increased in the urban areas (Gullota, 2006). Domestic violence in Kenya is mostly prevalent in middle-income and lower-income levels of the society. The rising levels of crime have also demonstrated new trends in the type of crime that women are experiencing, such as rape from carjacking. In 2009, a total of 3496 incidences of offences against morality (including rape, defilement, incest, among other offences) were reported, with the number rising to 3972 representing an increase of 14% (Kenya Police, 2010).

Currently there is no National Domestic Violence Call Centre in the country. The current modus operandi is that any domestic violence related distress calls are made to the police as victims usually do not know of any other sources of help. The police in turn have to rely on the description provided by the caller in order for them to locate the appropriate services. The most obvious choice for acquiring such information would be through paper-based inventory systems such as maps. This is cumbersome with respect to storage, retrieval, analysis and data update. Consequently, this process is more often than not slow, cumbersome and unreliable since in some cases police even have to ask their colleagues, casually, of the nearest services within the area depending on where the call is coming from. This also leads to reluctance by victims to report these cases and hence, suffer 'silently' without getting professional help be it legal and/or medical. It should be appreciated that even a few seconds of giving vital information can save victims lives.

1.1 Concepts applied in the research

A Geographical Information System (GIS) can assist in alleviating the suffering of victims by providing a streamlined set of tools allowing quick and efficient retrieval of location information, storing of such information and performing sophisticated spatial analyses. In this research the following concepts are applied and an overview of each is given.

Buffering: It involves the creation of a zone of a specified width around a point, line or polygonal area. The resulting buffer is a new polygon, which can be used in queries to determine which entities occur either within or outside the defined buffer zone (Aronoff, 1989). This technique was used to create buffers based on user-defined distances.

Spatial selection: This involves the selection of features that are within or outside the boundary defined by another feature dataset i.e. spatial intersection. The help providers were selected

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based on those which were within the buffer zones created from the buffering technique defined above. It performs such a task as: “Select all help providers within 1km radius from call origin location”.

Cartography: Cartography can be described as the graphic principles supporting the art, science, and techniques used in making maps or charts (Longley et al, 2005). The visualization of maps used to display the base map elements, base stations, help providers and common reference points were highly customized for the system view settings such that the scale and elements to be shown were highly optimized in terms of visual perception.

Interpolation: This is the process by which a surface is created, usually a raster data set, through the input of data collected at a number of sample points. There are several forms of interpolation, with each treating data differently, depending on the properties of the data set. Interpolation is justified on the basis of the “spatial autocorrelation principle” which recognizes that data collected at any position will have a great similarity to, or influence of those locations within its immediate neighbourhood. Interpolation was used to create raster datasets from number of calls values in the Call Origin feature class; this raster was used in the subsequent analysis when selecting suitable sites for setting up emergency help centers in an area.

Map algebra: This is the process of adding, subtracting, multiplying, and dividing maps by applying mathematical operations to map themes. Map algebra utilities allow the user to specify mathematical relationships between map layers (Longley et al, 2005; Melnick, 2002). This technique is used to add the cell values of the raster datasets which will be used when selecting the best site for setting up an emergency domestic violence help center based on the criteria specified

Database requirements: A GIS must allow the operator to: (a) Incorporate (import) data from outside sources. The method of updating the database that is to be employed in the system is by manually entering the data; this done by creating new geographic objects of interests. This technique is used to add a relatively small amount of new objects at a time. The DBMS will allow for error checking as new records are created or existing ones are updated. The system will also the provide the ability to create data files that can be exported to other systems in a common format which can be imported in other systems; in this case, creating KML format of the existing datasets.

(b) Easily update and alter data. Another common task will be updating or editing the database. Since no user can foresee all future data needs and applications, the system will provide ways to easily modify refine or correct the database. Attribute data are seldom static. Therefore, maintaining the currency of the data depends on updating the capability.

(c) Query the database. This refers to manipulating the database to answer specific data-related questions through a process known as database analysis. GIS systems take this a step further by performing spatial queries. The database management system (DBMS) software that is part of a GIS provides these capabilities.

This concept of spatially-enabled databases gives rise to a specialized DBMS referred to as geodatabase which is a database with extensions for storing, indexing, querying and manipulating geographic information and spatial data. The main benefit of a geodatabase is in the 'database type' capabilities that it gives to spatial data. Some of these capabilities include easy access of spatial data, the ability to easily link and join data tables, indexing and grouping of spatial datasets independent of software platform.

GIS open standards: These are specifications developed to address specific interoperability challenges between different formats and different kinds of spatial processing systems spearheaded by the Open Geospatial Consortium (OGC, 2006). It aims to come up with standard geographic file formats or components which are compatible with existing GIS systems and for the future even for customized mapping systems. Some of these formats include Geographic Markup Language (GML), Keyhole Markup Language (KML) (Google, 2008, Wikipedia 2006), Web Map Service (WMS), Web Feature Service (WFS), and Simple Features (SFS). National Spatial Data Infrastructures (SDI), specifically the proposed Kenya National SDI, require spatial information for sustainable development and economic decision making by different stakeholders involved and open standards facilitate the implementation of these initiatives; as such, the Call Centre system will solve part of the problem by publishing data held in the geodatabase to KML format for viewing in various systems which are freely downloadable from the internet. Most common of these are Google Earth, ArcGIS Explorer, GRASS GIS, and Quantum GIS. The main advantages of KML are: (a) it speeds the development of web-based mapping applications; (b) It encourages greater interoperability of existing GIS products; (c) It ensures easier movement of data between applications

1.1.1 System analysis and design

System design involves the generation of a design document which serves as a blue-print for the proposed system (Epstein, 1993). This document includes graphical depictions of the system structure as well as contextual material, which documents the pre- and post- conditions

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of the system components.

1.2 Research objectives

This research therefore set out to develop "*an on-screen GIS based solution that automatically identifies the general geographic area of the incoming phone number, allows search and selection of the appropriate services from a database of providers, map the location of the selection and is able to publish these maps in KML format*."

This objective is set to be achieved by satisfying the following sub-objectives: (i) enable an advocate to focus on a caller's individual needs such as the language (Kenya has 42 ethnic communities), medical, financial and psychological needs; (ii) decreased time required to find resources for the caller; (iii) move the caller to a safe place more quickly; (iv) act as a decision support tool on recommending sites for new help centers; (v) enhance information availability by publishing in open source standards.

2. Methodology

When designing any custom GIS solution, analysis of the functionality of the required output is necessary. This might include harnessing the strengths of each function and putting them together to solve real world problems in as short a time as possible (Stroustrup, 2009). As such the Kenya National Domestic Violence Call Centre (K-NDVCC) system brings together such techniques as cartographic modeling to represent features, raster analysis to selected sites to provide a comprehensive system to administer and manage most, if not all, spatially-related activities in a call centre. It is important to note that the results given by the system are dependent on the quality and integrity of the data held in the geodatabase. Also, they are dependent on the continual update of the database with time; hence, maintenance is an integral part of the development cycle of the system.

2.1 Pilot study area

Figure 2 show the study area considered in this work for testing the prototype. It is one of the sixteen locations in the larger Thika district of Kiambu County. It is a cosmopolitan location hosting the Jomo Kenyatta Univeristy of Agriculture and Technology which is the engine for most of the economic activities. It is relatively dry experiencing low rainfall and with temperatures ranging from 20°C - 35°C from the cold periods (June – July) and the hot periods (January – March). It had a population of 43,500 according to the 1999 census and a population density of between 264 – 416 persons per km^2 (NCAPD, 2005).

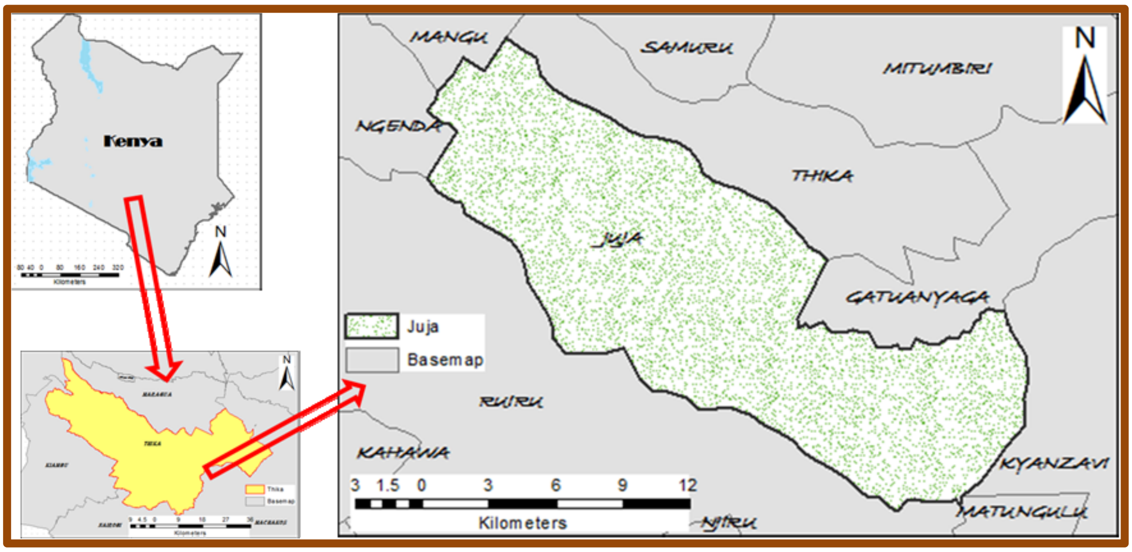

Figure 2: The pilot study area (Juja location) used for testing the prototype.

2.2 Database design

In order to come up with a compact and efficient database, the design process aimed to address the following issues: (i) The spatial database platform or environment to use; (ii) The kind of data that will be stored in the database; (c) The projection of this data i.e. whether projected or geographic; (d) The organization of the object classes such as tables, feature classes, topology rules and shapefiles.

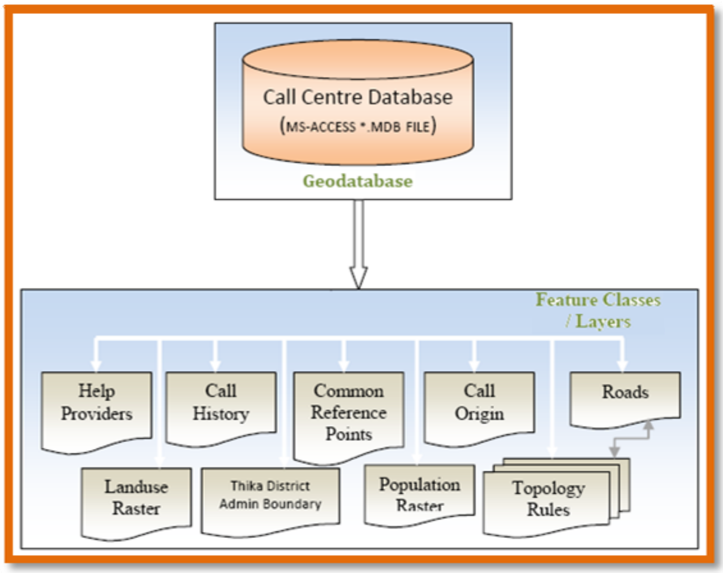

Figure 3: The call center data model.

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The overall aim was to design a database that met the system requirements and performed well. Consequently, a good design ensures that data retrieval is fast and efficient. Figure 3 shows the data model adopted in this research. Tables 1 – 4 shows the spatial object classes created together with their individual properties/attributes:

Table 1: Help providers feature class.

Field Name	Data Type	Domain Name
Name*	String	-
Alias	String	-
Category*	String	Provider Category
Contact Person*	String	-
Night Contact Person	String	-
Counsel Service*	Boolean	-
Medical Service*	Boolean	-
Location*	String	-

Table 2: Common reference point feature class.

Field Name	Data Type	Domain Name
Name*	String	-
Alias	String	-
Description*	String	-

Table 3: Call history feature class.

Field Name	Data Type	Domain Name
Call Location*	String	-
Time of Call*	Date/Time	-
Sex of Caller*	String	Caller Gender
Domestic Violence Category*	String	Call Nature
Age*	Integer	-
Marital Status*	String	Marital Status
Comments	String	-
User*	String	-

Table 4: Call origin/Base station feature class.

Field Name	Data Type	Domain Name
Name*	String	-
Unique Code Identifier	String	-
Location*	String	-
Number of Calls*	Long	-
Area Category*	String	Area Category

2.3 System analysis and design

System analysis involved careful study of the requirements with regard to development of the solution. It entailed: (i) *Fact finding* **–** This was done by building undersatanding of the reporting mechainisms currently in place addressing domestic violence. From this understanding, the strengths and weaknsess of the mechanisms will be identified and used to inform the formulation of strategies to address the limitations. (ii) *Recording of facts* **–** This was done at every stage where all the data acquired was verified, checked for relevance and then recorded for use. (iii) *Compiling of data* **–** All the collected data was compiled to form a meaningful sequence of activities to be done to achieve the objectives.

System design was the most crucial stage in this research where features of the new system were specified. The activities involved in system design were: (a) Program flowcharting, which is a detailed data flow diagram (DFD) of the project activities. (b) Design of the graphical depiction required to make the flow of the program logical and consistent with the flowcharts constructed. (c) Design of the geodatabase to accommodate the geographic datasets required to run the system, and (d) Design of the required output formats. The design of the system was structured, since it is the blue print of the automated solution to a given problem (Stroustrup, 2009; Tucker et al, 1995). The tools and techniques used for design include: (a) Flowcharts; (b) Data Flow Diagrams; (c) Data Dictionary; (d) Structured English and (e) Decision table. The system developed in this research comprises of 4 modules: (a) Display query-defined features; (b) Spatial Analysis; (c) Export to KML and (d) Database editing

2.3.1 Display Query-Defined Features

This is the main module which will provide the *advocate* with the interface to capture caller details (figure 4). The system will simulate the automatic call location by loading the location of the Base Stations (referred to as Master Switching Stations) in a list from where the advocate will select the specific location and then will quickly access accurate information about the nearby resources i.e. the help providers/centers.

In this module, the location field of the Call Origin feature class is referenced by the system such that it populates the Call Location field in the Caller Details form. The advocate will then fill the particular caller needs, which once appropriately entered and the *Query* Command hit, the system will automatically create a buffer (whose distance is dependent on the area category of the call location i.e. urban, semi-urban or rural) and search for Help Provider features which are contained within the buffer. If a Help Provider centre (such as a Police Station) is found then a tag will be placed on the digital map identifying the characteristics of the feature; on the other hand, if no features are found, a user-defined increment will be applied on the initial buffer distance according to

$$Buffer\ distance = Buffer\ distance + Increment$$

The Buffer distance will be incremented 3 times and if no features are found then advocate will be notified that no features (Help Providers) were found.

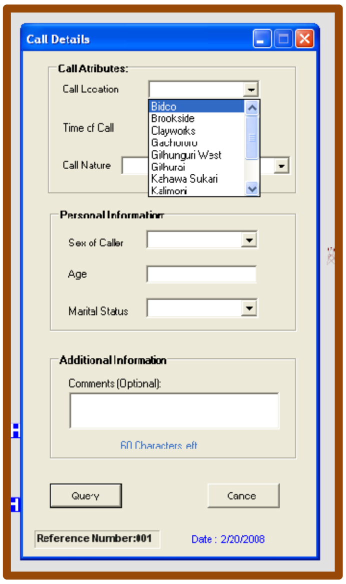

Figure 4: Caller detail form.

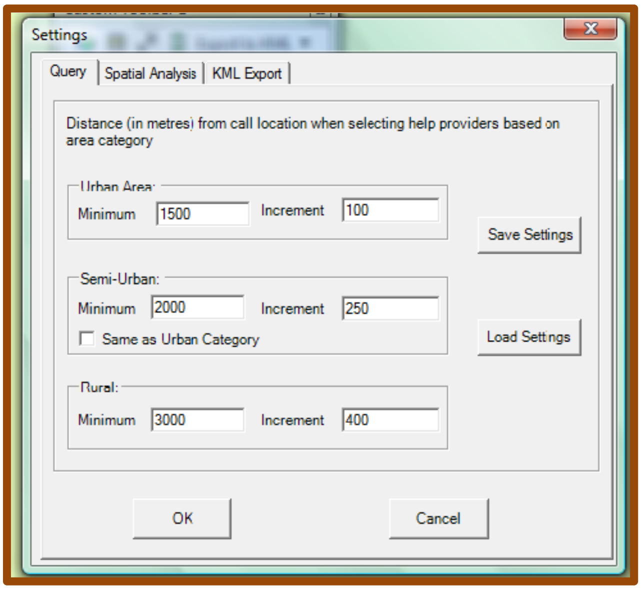

Figure 5: Query settings interface.

The system is customizable such that the minimum buffer and increment distance can be specified by the user or some defaults values can be used. If a user wishes to define the minimum buffer and incremental distance and save them in computer memory for future reuse. Figure 5 shows the interface for specifying the minimum and increments for the various land use categories.

2.3.2 Spatial Analysis

This module is used to generate suitability maps when one needs to set up an emergency help center in area based on specific parameters which directly influence its justification and existence. These parameters are subjective and are subject to modification and addition based on the specific needs which may arise once the system is up and running. These parameters are: (i) Number of domestic violence related calls received through each base station, (ii) the distance from nearest help facility, (iii) distance from the road, (iv) land use and (v) population. Figure 6 shows the spatial analysis dialog.

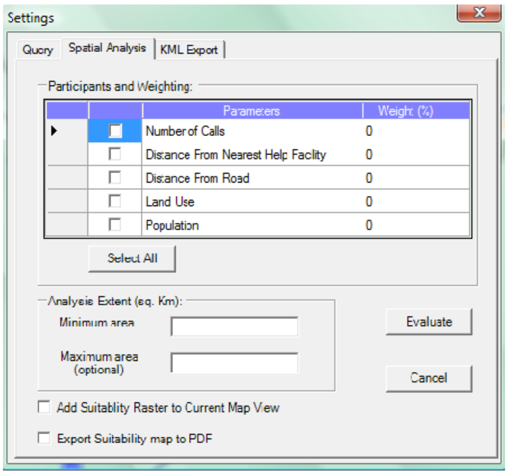

Figure 6: Spatial analysis dialog.

Spatial analysis is based on cell-based modeling of each parameter meaning that they have to be in raster format in order for the analysis to take place. For the number of calls through each base station parameter, interpolation (kriging) of the numerical value of the calls for each base station is used to generate the raster surface; Euclidian (or straight line) distance is used to generate the numerical value distance of each source point to the next nearest point for both the distance from nearest help facility and distance from road parameters.

Using geoprocessing tools available, the land use and population parameters are converted to raster datasets using land use type and population number respectively. A reclassification of the values of the each cell of each raster participating in the analysis is done by altering the values of these cells. This is done so as to assign the values of the raster datasets to a common scale through relative weighting of the minimum and maximum of cell values within each raster dataset. In this case, a scale of 1 to 10 was used to reclassify the cells of each raster dataset, with 1 being the most suitable and 10 the least suitable. Hence, the suitability criteria would be as follows: highest number of calls most suitable (assigned value 1 during reclassification) and least number of calls (assigned 10); should be further away from nearest help facility hence, the greater the distance the more suitable (assigned 1); should be nearer the road such that the smaller the distance the more suitable (assigned 1); in land use, town type of land use is most suitable (assigned 1) while forest least suitable, and since the study area (Thika) is within an agricultural zone then not all land uses are represented in the suitability modeling but the rest can always be included if the system were to be fully implemented countrywide; finally, should be in an area with high population such that the higher the population the more suitable (assigned 1). The final step involves weighting the reclassified raster datasets through map algebra and overlay techniques. The weighting is based on those specified in the SPATIAL ANALYSIS tab in the system settings. The output of the map algebra cell-addition is a new raster showing the classification of the suitability range of areas based on the parameters selected and the respective weights assigned.

2.3.3 Export to KML

This module simply exports the visible layers in the map or the map document to KML format; once they have been created, the user is requested whether to open them in Google Earth. The output paths to the two options can be set by the user in the KML EXPORT tab which are saved in a text document and as defaults to be loaded at the start of a new session.

2.3.4 Database Management

This module provides the necessary interface required to carry out routine database management tasks (add item, edit item and delete item) in the 3 core feature classes that uniquely identify the geodatabase i.e. Help Providers, Base Station and Common reference Points feature classes. It is designed in such a manner that the attribute fields for each feature class are clearly labeled requiring only the user to provide the correct corresponding values. With regard to the spatial coordinates of each feature, all that is required are the GPS Northings/Southings and Eastings decimal degrees values obtained in the field and the system will automatically convert them to the required Universal Transverse Mercator projected (UTM) coordinates.

3. Data collection

In this research, location data (x, y) of spatial objects such as help providers and mobile phone base stations were collected, with their corresponding non-spatial attributes such as name, location, and category were recorded.

3.1 Data sources

The main data capture methods used in the research were (a) Global Positioning Systems (GPS), (b) Google Earth and (c) Topographical maps

3.1.1 GPS

Global Positioning System is a space-based radio navigation system consisting of 24 satellites and ground support, providing users with accurate information about their position and velocity. Point features (i.e. help providers and base stations) positions were collected using GPS civilian signal gained an average accuracy of ±10m which was sufficient for this work. A Garmin GPS 60 was used and which enabled the accompanying names of the features to be recorded in its inbuilt memory for future transfer to a computer system. Non-spatial attribute information was recorded on paper against the name of the particular feature. The saved features were then transferred into a new database. Non-spatial attributes were directly entered into the database. The resulting database was merged with the geodatabase feature class to form a uniform database.

3.1.2 Google Earth

This is a virtual globe program which maps the earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS 3D globe. For most part of the study area, the freely available remote sensing dataset of Google Earth was found to be of adequate resolution. It was used to digitize road features due to coincidence with the GPS tracks over the same road features.

3.1.3 Topographical Maps

In reasearch, topographical maps for Juja and Thika were used to provide base data for digitizing road features in those instances where Google Earth imagery was of a coarse resolution or was severely impeded by cloud cover.

3.2 Data processing

This involved preparation of data into forms suitable for use within the GIS system. This involved projecting the vector data to their required reference, creating fields for each specific feature class. Generally, the tasks involved here encompass assigning map co-ordinates and spatial location, transforming between different reference systems, creating fields and assigning attributes to individual features. All the datasets in the geodatabase were projected to Universal Transverse Mercator (UTM) Zone 37 South.

4. Results and discussion

To verify the accuracy and correctness of the output of the program against the expected design procedures, sample system GIS routines were performed in parallel with those automated in the solution.

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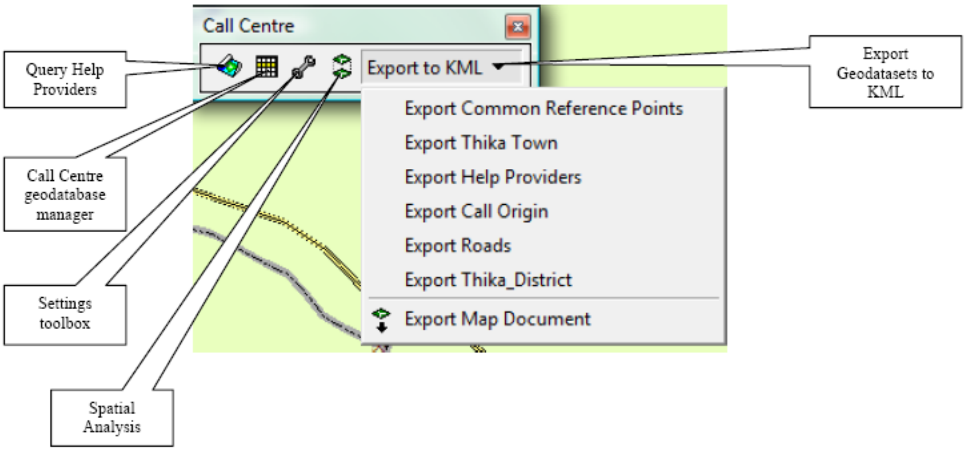


Figure 7: Call center toolbox as a GIS extension.

The sample sites used are within the study area and the results are assumed to be consistent even for other areas within the country implying scalability and extensibility. This is equivalent to testing the system by providing it with a specific problem in terms of particular domestic violence scenarios and assessing whether the results outputted by the system match with expected results, in some cases by manually carrying out the individual GIS techniques and using the outputs from one process as input to the subsequent process. This is done at a modular level on the four modules that constitute the system. These are uniquely grouped together in a separate toolbar with the commands clearly marked and contain tool tips which summarize the functionality of each command, and a settings tool which enables the user to customize the operations of the system. This toolbar is illustrated in figure 7.

4.1 Automated help providers location

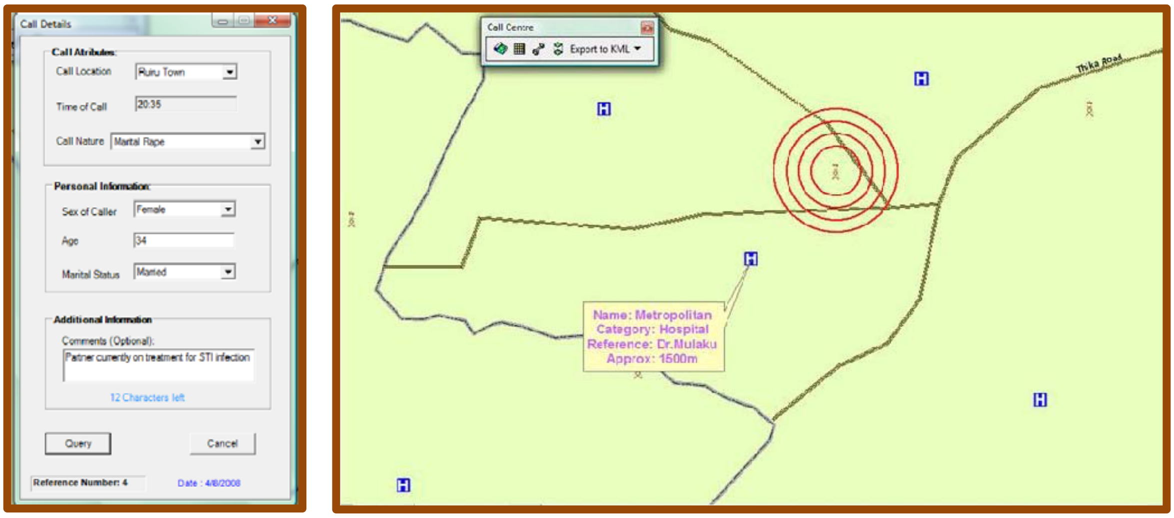
***Problem*:** A female caller in her mid-thirties, who is married, suffers from marital rape inflicted by her partner who is currently under medication for a sexually transmitted infection (STI). The locality of the call is coming from is Juja Town. The query distance parameters are set as in Table 5.

Table 5: Automated help provider parameters.

Area Category	Minimum Distance	Increment
Urban Area	1500	100
Semi Urban Area	2000	250
Rural Area	3000	400

Figure 8 shows the origination of the distress call and based on the help provider parameters, the call center can inform the distressed caller the nearest help provider, including details of how to get to the help (moving her from the danger to safety), who to contact at the facility, the type of facility and the distance from the caller to the facility.

The results are automatically written to the geodatabase allowing study of history and trends which maybe of importance to various stakeholders who may want to study these relationships and patterns together with dependent external factors. The table contents are reproduced in figure 9.



(a) (b)

Figure 8: Caller details input form (a) and the corresponding query results map (b).

OID	CallLoc	CallTime	CallerSex	CallNature	Age	MStatus	Referral	Tribe	RefNum	Comments
0	Brookside	4/7/2008	Male	Verbal Abuse	36	Married	Unavalable		1	Harrassment
1	Bidco	4/7/2008	Male	Sexual Abuse	56	Single	Thika District		2	Divorced
2	Githurai	4/8/2008	Female	Marital Rape	34	Married	Metropolitan		3	Partner on treatment for STI

Figure 9: geodatabase table results persisting the entries.

4.2 Database management

The three main database tasks (add, edit and delete) for the three core feature classes (i.e. Common Reference Points, Help Providers and Call Origin) will not be highlighted in paper for each scenario. This module solves the following sample problems.

Problem 1 (Insertion): The following data has been collected from the field using a GPS and

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details for the *Help Provider* recorded in a specially designed paper form. The spatial reference is given as: Southings = -1.165530°, Eastings = 36.96856°, with properties of the help centre are highlighted in a user form.

Problem 2 (Update): Senate Hotel, stored in the database as a common reference point, has its name changed to Hill Springs Hotel.

Problem 3 (Deletion): The mobile service provider has decided to discontinue and decommission the base station with the unique ID CTL9101X. Hence, this feature has to be deleted from the Call Origin database.

4.3 Export geodatasets to KML

Problem: Export the following geographic datasets that to KML format. They include Common Reference Points, Thika Town, Call Origin and Roads. The resulting file should be viewable in various freeware and open source software supporting this format.

4.4 Spatial analysis

Problem: A new emergency help centre is to be setup within Juja town. The minimum analysis area is to be 30 km^2, the parameters that are to be included in the analysis are: Number of calls (Weight - 60%), Distance to Nearest Help Centre (Weight - 35%) and Distance from Road (Weight- 5%). Figure 10 captures these settings. This allows users finer control on the weighting (relevance) of the layers (rasters) in determining the location of the new facility. The current user has selected the option of adding the suitability raster to the current view once the analysis is complete.

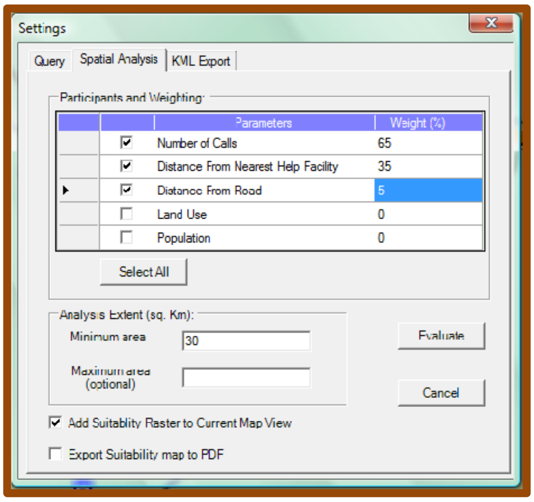

Figure 10: Spatial analysis settings.

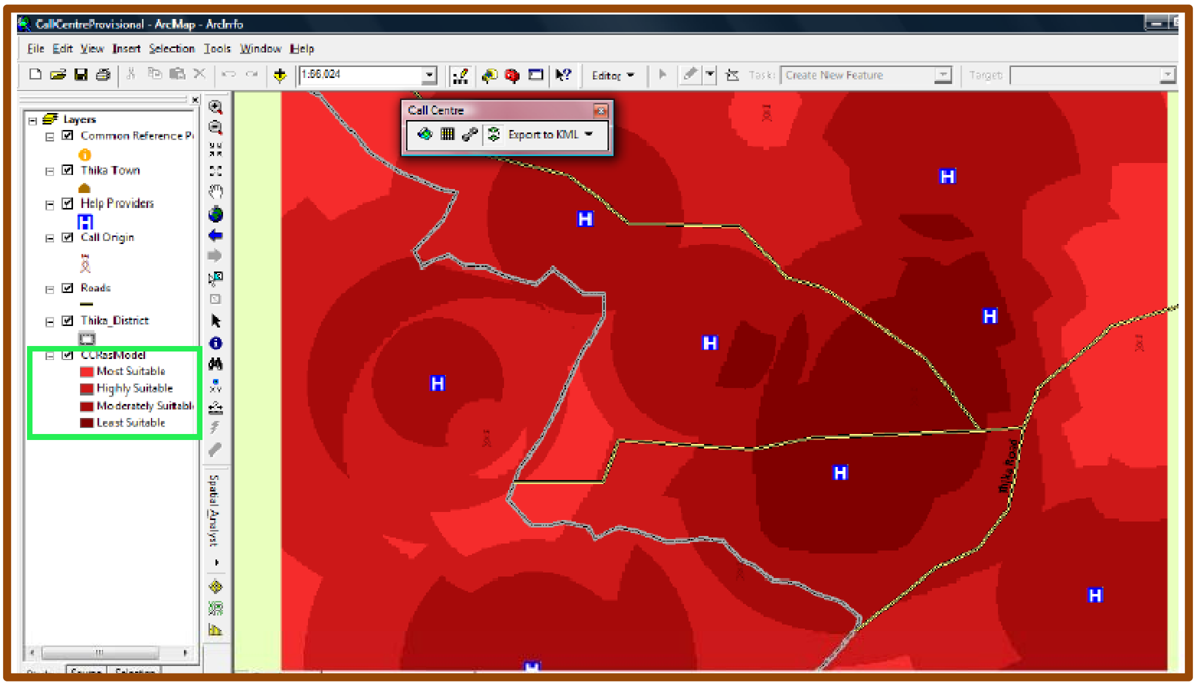

Figure 11: Spatial analysis results.

Figure 11 shows the area suitability for setting up an emergency domestic violence help center as generated by the prototype system. Notice the classification is done automatically by the system based on 4 natural break classification categories – highlighted in the map legend by the green -outlined rectangle. The analysis is based on the parameters which are deemed to have the greatest influence but are subject to modification and enhancement if the system is adopted at the national level. The SPATIAL ANALYSIS parameters can be tweaked with different values to come up with various suitability scenarios

5. Conclusion

In this work, the prototype developed has shown the ability to quickly and efficiently connect a distressed caller to a help advocate who is also informed on the location of the caller so that immediate remedial actions can be taken to move him/her to safety. This system is thus able to minimise the risks of continued abuse by reducing the time taken to get to the aggrieved person. This system is also able to produce analyses that can be used to inform decisions on the location of new advocates, e.g. depending on the frequency of distress calls, levels of violence severity and distances to the nearest existing respondents.

For each program module, the results obtained compared exceptionally well to those computed manually from digital maps showing the integrity of the system in terms of accuracy and speed of data selection and display showing that it is possible to do complex spatial operations very fast. This is especially significant since every second lost before moving the caller to safety can have serious ramifications, sometimes to the extent of death.

This solution has demonstrated its potential and it is necessary to fully automate all the GIS processes in the Call Centre system. An aspect that must be given due attention is the quality of the data that is referenced by the system as the accuracy of the information given by the advocate is solely dependent on the underlying database. This system used base stations as call originators for simplicity, however, in the eventual implementation, the actual call location can be identified by utilizing Global System for Mobile communication (GSM) technology, with very minimal modification to the source code. The synergy leading to GSM – based GIS services has huge potential in such fields as fleet management, logistics and stolen vehicle tracking applications, road-side assistance, medical emergency services and crime-response services. The same concepts can be applied in these applications such that their implementation and maintenance times will be much shorter as they will share the same components i.e. geographic datasets and automated GIS processes.

While this system has been implemented based on the ArcGIS*tm* software system, the concepts used in implementing the prototype are generic and it can thus be implemented in any other GIS platform such as GeoMedia*tm*, MapInfo*tm*, GRASS and Quantum GIS.

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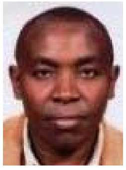

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